# APPLICATION UNDER UNITED STATES PATENT LAWS

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Invention:   INFORMATION RECORDING MEDIUM, INFORMATION RECORDING APPARATUS, AND INFORMATION RECORDING METHOD

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## This is a:

☐ Provisional Application

☒ Regular Utility Application

☐ Continuing Application
  ☐ The contents of the parent are incorporated
    by reference

☐ PCT National Phase Application

☐ Design Application

☐ Reissue Application

☐ Plant Application

☐ Substitute Specification
  Sub. Spec Filed _____
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  Sub. Spec. filed _____
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# SPECIFICATION

TITLE OF THE INVENTION

INFORMATION RECORDING MEDIUM, INFORMATION RECORDING
APPARATUS, AND INFORMATION RECORDING METHOD

CROSS-REFERENCE TO RELATED APPLICATIONS

5      This application is based upon and claims the
benefit of priority from the prior Japanese Patent
Application No. 2002-193388, filed July 2, 2002, the
entire contents of which are incorporated herein by
reference.

10                BACKGROUND OF THE INVENTION

       1.  Field of the Invention

       The present invention relates to an information
recording medium which comprises a defect management
area for storing defect management information.  The

15     present invention also relates to an information
recording apparatus for recording defect information on
an information recording medium.  The present invention
further relates to an information recording method for
recording defect information on an information

20     recording medium.

       2.  Description of the Related Art

       An information storage medium such as an optical
disk or the like has a user area used to store user
data, and has a mechanism for compensating for defects

25     generated in this user area.  Such mechanism is called
a replacement process.  An area that manages
information associated with this replacement process,

i.e., defect management information, is called a DMA (Defect Management Area).

Of information recording media, a DVD-RAM allows 100,000 or more overwrite accesses. Even when the DMA of such medium with very high overwrite durability undergoes several ten thousand overwrite accesses, the reliability of the DMA never wavers.

Jpn. Pat. Appln. KOKAI Publication No. 9-213011 discloses an optical disk having a plurality of DMAs. By allocating a plurality of DMAs, the DMA reliability can be improved.

However, in case of an information recording media having a relatively small allowable overwrite count (several ten to several thousand times), overwrite accesses to a DMA of such medium pose a problem. That is, the DMA of such medium is easily damaged by overwrite accesses.

This problem cannot be solved even by a technique disclosed in Jpn. Pat. Appln. KOKAI Publication No. 9-213011. That is, even when a plurality of DMAs are allocated, since respective DMAs undergo overwrite accesses at the same time, if one DMA is damaged by overwrite accesses, other DMAs are also damaged.

Each DMA stores defect management information, as described above, and if the DMA is damaged, defect management information cannot be read out from the DMA. As a result, the medium itself can no longer be used.

Hence, it is demanded to improve the overwrite durability of the DMA.

## BRIEF SUMMARY OF THE INVENTION

An information storage medium according to an aspect of the present invention comprises a user area to store user data, a defect management area to store defect information associated with defects on the user area, and an overwrite management area to store overwrite information associated with an overwrite count for the defect management area.

An aspect of the present invention is directed to an information recording apparatus for recording information on an information recording medium, which has a user area to store user data, a defect management area to store defect information associated with defects on the user area, and an overwrite management area to store overwrite information associated with an overwrite count for the defect management area, comprising: a recording unit to record the user data, the defect information, and the overwrite information; and a recording control unit to control the recording unit to record the defect information on the defect management area, and to record the overwrite information on the overwrite management area in correspondence with the recording operation.

An aspect of the present invention is directed to an information recording method for recording

information on an information recording medium, which has a user area to store user data, a defect management area to store defect information associated with defects on the user area, and an overwrite management

5    area to store overwrite information associated with an overwrite count for the defect management area, comprising: recording the defect information on the defect management area, and recording the overwrite information on the overwrite management area in

10   correspondence with the recording operation.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWING

The accompanying drawings, which are incorporated in and constitute a part of the specification, illustrate presently preferred embodiments of the

15   invention, and together with the general description given above and the detailed description of the preferred embodiments given below, serve to explain the principles of the invention.

FIG. 1 shows an outline of the data structure of

20   an information storage medium (optical disk) according to an embodiment of the present invention;

FIG. 2 is a flow chart showing an example of a replacement process;

FIG. 3 shows an example of a schematic data

25   structure of a DMA allocated on the information storage medium;

FIG. 4 shows an example of contents described in

a first sector of a DDS/PDL block contained in the DMA;

FIG. 5 shows an example of contents described in an SDL block contained in the DMA;

FIG. 6 shows an example of the data structure of one of a plurality of SDL entries contained in an SDL;

FIG. 7 is a state transition chart for explaining an example of a method of using a DMA sequence;

FIG. 8 shows the relationship (part 1) between the states of counters allocated in DMAs and DMA transition;

FIG. 9 shows the relationship (part 2) between the states of counters allocated in DMAs and DMA transition;

FIG. 10 is a flow chart showing an example of a sequence for searching for a currently active DMA;

FIG. 11 is a flow chart for explaining an example of DMA registration and update processes;

FIG. 12 is a state transition chart for explaining an example of a method of using a plurality of DMA sequences;

FIG. 13 is a view for explaining an example of lead-in and lead-out areas where a plurality of DMA sequences are allocated;

FIG. 14 is a flow chart showing an example of a reproduction process of a medium on which a plurality of DMA sequences are allocated; and

FIG. 15 is a schematic block diagram showing the

arrangement of an information recording/reproduction apparatus according to an embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

A preferred embodiment of the present invention will be described hereinafter with reference to the accompanying drawings.

FIG. 1 shows an outline of the data structure of an information storage medium (optical disk) according to an embodiment of the present invention. As shown in FIG. 1, an information storage medium has a data structure which comprises a spare area SA and user area UA between DMAs. Note that the data structure shown in FIG. 1 is merely an example of that of the information storage medium of the present invention, and the data structure of the information storage medium of the present invention is not limited to such specific data structure.

The user area UA is used to store user data. The spare area SA is an area where data to be recorded on a defective area present within the user area is replacement-recorded. The defective area is an area for respective ECC (Error Correction Code) blocks. That is, data for respective ECC blocks is replacement-recorded on the spare area SA. As will be described later, each DMA comprises a DMA counter (overwrite management area). The overwrite count on

the DMA is reflected on the count value of the DMA counter.

FIG. 2 is a flow chart showing a replacement process. As shown in FIG. 2, data to be recorded on
5    a defective area generated in the user area is replacement-recorded on the spare area SA (ST1). In addition, the start addresses of the replacement source (defective area) and replacement destination (a predetermined area in the spare area SA) are
10   registered in an SDL (Secondary Defect List) in each DMA. The DMAs are allocated on the inner and outer peripheries of the information recording medium, as shown in, e.g., FIG. 1, and identical data is registered in the SDLs of both the DMAs. When
15   information is registered in each SDL, an update counter of the SDL is incremented (+1) (ST2).

Conventionally, a DMA is allocated at a fixed physical address on a medium. Furthermore, in order to improve the fault tolerance of the DMA, DMAs that store
20   identical contents are allocated at a plurality of locations on the medium. For example, in case of a DVD-RAM, DMAs are allocated at two locations on the innermost periphery and two locations on the outermost periphery, i.e., a total of four locations, and these
25   four DMAs record identical contents.

FIG. 3 is a schematic view showing the data structure of DMAs allocated on the information storage

medium of the present invention.  As shown in FIG. 3,
the information storage medium has a plurality of DMAs,
each of which is made up of DDS/PDL blocks and SDL
blocks.  "PDL" is an abbreviation for Primary Defect

5    List.  Each of the DDS/PDL and SDL blocks corresponds
to one ECC block (= 32KB).

In order to improve the fault tolerance of DMAs,
when an active DMA has weakened, the information
storage medium according to an aspect of the present

10   invention is defined to shift defect management
information stored in that DMA to a new DMA.  It is
determined that the DMA has weakened when the overwrite
count of this DMA approaches an allowable overwrite
count of the medium having the DMA, or when defects on

15   this DMA increase, and error correction is more likely
to fail.

Each DMA has a size of an integer multiple of that
of an ECC block as a true recording unit in a drive.
On a DVD-RAM, one ECC block consists of 16 sectors, and

20   the size of one ECC block is 32KB.  A PDL is a primary
defect registration list, and an SDL is a secondary
defect registration list.  The PDL registers defect
information associated with defects found in
certification executed upon formatting a medium, i.e.,

25   primary defects.  By contrast, the SDL registers defect
information associated with defects found upon normal
recording (e.g., upon recording user data), i.e.,

secondary defects.  The defect management information contains a replacement source address and replacement destination address.  When the sizes of these lists increase, the number of defects that can be registered increase.  DMA0 to DMAn are sequentially allocated, and are used in turn from DMA0.

FIG. 4 shows an example of contents described in the first sector of the DDS/PDL block contained in the DMA.  On a predetermined area of the DDS/PDL block, a 4-byte DDS/PDL update counter, 4-byte DMA rec-counter 1, and the like are allocated.

Every time the contents of the DDS/PDL block are updated, the DDS/PDL update counter is incremented (+1).  The DMA rec-counter 1 is counted up when the DDS/PDL block is rewritten.  At the time of initialization (first time) of the medium, zero is set in all DMA rec-counters 1.  A method of using this counter will be described later.

FIG. 5 shows an example of contents described in the SDL block contained in the DMA.  On a predetermined area of the SDL block, a 4-byte SDL update counter, 4-byte DMA rec-counter 2, and the like are allocated.

As in the DDS/PDL block, every time the contents of the SDL block are updated, the SDL update counter is incremented (+1).  The DMA rec-counter 2 is counted up when the SDL block is rewritten.  The SDL describes management information associated with secondary

defects. At the time of initialization (first time) of the medium, zero is set in all DMA rec-counters 2. A method of using this counter will be described later.

FIG. 6 shows an example of the data structure of one of a plurality of SDL entries contained in the SDL. One SDL entry consists of, e.g., 8 bytes. On one SDL entry, a 3-byte field for describing the replacement source address, and a 3-byte field for describing the replacement destination address are allocated. A replacement process is done for, e.g., respective ECC blocks. The replacement source address field and replacement destination address field respectively register the addresses of first sectors contained in respective ECC blocks. In the example of the data structure shown in FIG. 6, 3-byte fields are assigned to designate addresses. However, when a medium has a larger capacity (larger address space), the address designation field size increases.

FIG. 7 is a state transition chart for explaining the method of using a DMA sequence. The DMA sequence comprises (n + 1) DMAs from DMA0 to DMAn. If DMA0 is a currently active DMA, DMA1 to DMAn are auxiliary DMAs.

A plurality of DMAs included in the DMA sequence are used in turn from DMA0. In an initial state, DMA0 is used, and DMA1 and subsequent DMAs are not used. When defects on DMA0 increase, or when the overwrite

count has exceeded a prescribed value, DMA0 becomes

a used area, and defect management information stored

in DMA0 is replaced to and recorded on DMA1.  Likewise,

using DMAs in turn, even when each DMA has suffered

5    defects or overwrite damages, the medium can be

continuously used without breaking down as a system.

FIG. 8 shows the relationship (part 1) between

the states of counters allocated in DMAs and DMA

transition.  The DDS/PDL update counter and SDL update

10   counter shown in FIG. 8 are cumulative counters which

cumulatively count even when DMA transition has

occurred (even after transition of DMA0 $\rightarrow$ DMA1).

As shown in FIG. 8, a DMA counter is allocated on

a predetermined area of a DMA.  This DMA counter is

15   incremented when the DMA is rewritten.  That is,

a larger one of the count value of the DMA rec-counter

1 of the DDS/PDL block contained in the DMA and that of

the DMA rec-counter 2 of the SDL block contained in the

DMA is the count value of the DMA counter.

20   More specifically, by checking the count value of

this DMA counter, the overwrite count of the currently

active DMA can be detected.  In other words, the count

value of the DMA counter is a value indicating the

level of damage that the DMA suffers upon overwrite

25   accesses on the DMA.

The information recording/reproduction apparatus

for recording information on this medium shifts the

currently active DMA (e.g., DmA0) to an auxiliary DMA (e.g., DMA1) within the range of the allowable overwrite count (Nov) which is determined in accordance with the characteristics of a medium. Of course, in

5      order to fully effectively use the currently active DMA, it is desirable to use that DMA until the maximum value (Nov-1) of the DMA counter. Even when the DMA counter does not reach its maximum value, the information recording/reproduction apparatus shifts

10     the currently active DMA to an auxiliary DMA if it detects an increase of defects on the currently active DMA. Each DMA receives a value only after it begins to use. That is, no value is input to unused DMAs. When a medium is loaded to the information

15     recording/reproduction apparatus, the information recording/reproduction apparatus searches for a DMA in which the count values of both DMA rec-counters 1 and 2 are zero, so as to detect the location of the currently active DMA. If a DMA (e.g., DMA2) in which the count

20     values of both DMA rec-counters 1 and 2 are zero is found, the apparatus recognizes a DMA (e.g., DmA1) immediately before the found DMA as the currently active DMA. If no DMA in which the count values of both DMA rec-counters 1 and 2 are zero is found, the

25     apparatus recognizes the last DMA (e.g., DMAn) as the currently active DMA.

        FIG. 9 shows the relationship (part 2) between

the states of counters allocated in DMAs and DMA
transition.  The case has been explained above with
reference to FIG. 8 wherein the DDS/PDL update counter
and SDL update counter cumulatively count even when DMA
transition has occurred.  By contrast, FIG. 9 will
explain a case wherein the count values of the DDS/PDL
update counter and SDL update counter are reset
when DMA transition has occurred (after transition of
DMA0 → DMA1).

As shown in FIG. 9, a DMA counter is allocated on
a predetermined area of a DMA.  This DMA counter is
incremented when the DMA is rewritten.  That is,
a larger one of the count value of the DDS/PDL update
counter (DMA rec-counter 1) of the DDS/PDL block
contained in the DMA and that of the SDL update counter
(DMA rec-counter 2) of the SDL block contained in the
DMA is the count value of the DMA counter.

In the case shown in FIG. 9, every time the DMA
shifts, the DDS/PDL update counter and SDL update
counter are reset.  For this reason, the DDS/PDL
update counter has a function equivalent to that of the
DMA rec-counter 1, and the SDL update counter has
a function equivalent to that of the DMA rec-counter 2.
Therefore, in the case shown in FIG. 9, DMA
rec-counters 1 and 2 may be omitted.

FIG. 10 is a flow chart showing the sequence for
searching for the currently active DMA.  The search

process for searching for the currently active DMA is
executed by a main controller 20 of the information
recording/reproduction apparatus shown in FIG. 15.
As described above, the information storage medium

5      of the present invention is defined to shift DMAs
upon overwrite accesses and the like.  Therefore,
when a disk is loaded to the information
recording/reproduction apparatus, the currently active
DMA must be searched for.  The DMA rec-counters 1 and 2

10     are allocated on each of DMAs (DMA0 to DMAn) on the
medium.  When the medium is initialized, the count
values of the DMA rec-counters 1 and 2 of each DMA are
set to zero.  When the medium begins to use, the count
values of the DMA rec-counters 1 and 2 of DMA1 are

15     counted up.  When use of the medium further continues,
the count values of the DMA rec-counters 1 and 2 of
DMA2 are counted up.  The use order of DMA0 to DMAn is
predetermined.  That is, the DMAs are used in the order
of DMA0 $\rightarrow$ DMA1 $\rightarrow$ DMA2 $\rightarrow$ ... $\rightarrow$ DMAn.  Hence, by

20     checking the count values of the DMA rec-counters 1
and 2 of DMA0 to DMAn, the currently active DMA can be
found out.

As shown in FIG. 10, when the medium is loaded to
the information recording/reproduction apparatus, the

25     information recording/reproduction apparatus searches
for a DMA in which the count values of both DMA
rec-counters 1 and 2 are zero, so as to detect the

location of the currently active DMA (ST21). If a DMA (e.g., DMA2) in which the count values of both DMA rec-counters 1 and 2 are zero is found (ST22, YES), the apparatus recognizes a DMA (e.g., DMA1) immediately

5 before the found DMA as the currently active DMA (ST24). If no DMA in which the count values of both DMA rec-counters 1 and 2 are zero is found (ST22, NO), the apparatus recognizes the last DMA (e.g., DMAn) as the currently active DMA (ST23).

10 FIG. 11 is a flow chart for explaining DMA registration and update processes. The DMA registration and update processes are executed by the main controller 20 of the information recording/reproduction apparatus shown in FIG. 15.

15 The main controller 20 checks based on the count value of the DMA counter of the DMA if the rewrite count of the currently active DMA has exceeded a prescribed value (ST31). If it is determined that the rewrite count has exceeded the prescribed value (ST31, YES),

20 the main controller 20 confirms if defect information stored in the currently active DMA can be shifted (if an auxiliary DMA remains). If it is determined that defect information can be shifted (ST34, YES), the main controller 20 shifts defect information stored in the

25 currently active DMA to a DMA determined as the next shift destination (ST35). At this time, required values are taken over. For example, in the case shown

in FIG. 8, the values of the DDS/PDL update counter and
SDL update counter are taken over.

Even if the rewrite count is equal to or smaller
than the prescribed value (ST31, NO), if the main
controller 20 detects that many defects are generated
in the DMA (ST32, YES), the controller 20 confirms if
defect information stored in the currently active DMA
can be shifted (if an auxiliary DMA remains). If it is
determined that defect information can be shifted
(ST34, YES), the main controller 20 shifts defect
information stored in the currently active DMA to a DMA
determined as the next shift destination (ST35). If it
is determined that defect information cannot be shifted
(ST34, NO), this process terminates abnormally.

If the rewrite count of the currently active DMA
is equal to or smaller than the prescribed value (ST31,
NO) and if the currently active DMA does not suffer
defects (ST32, NO), the currently active DMA is updated
as needed (ST33).

FIG. 12 is a state transition chart for explaining
an example of a method of using a plurality of DMA
sequences. As shown in FIG. 7, use of a single DMA
sequence has been explained so far. That is, the case
has been explained wherein one DMA sequence includes
DMA0 to DMAn. In this case, use of a plurality of DMA
sequences, as shown in FIG. 12, will be explained.
That is, a case will be explained wherein each of

a plurality of DMA sequences includes DMA0 to DMAn.

As shown in FIG. 12, for example, an information storage medium having four DMA sequences will be explained. The four DMA sequences are allocated at different locations. For example, DMA sequences 1 and 2 are allocated on the innermost periphery of the medium, and DMA sequences 3 and 4 are allocated on the outermost periphery of the medium. Assume that many defects are generated in, e.g., DMA sequence 3 of DMA sequences 1 to 4 (initial state of FIG. 12). The main controller of the information recording/reproduction apparatus shown in FIG. 15 detects the presence of many defects. Upon detection of defects, defect management information in each of currently active DMAs (e.g., DMA0) in all the DMA sequences is shifted (undergoes) replacement recording) to the next DMA (e.g., DMA1) (second state in FIG. 12). The main controller of the information recording/reproduction apparatus shown in FIG. 15 shifts (executes replacement recording of) the defect management information.

FIG. 13 is a view for explaining lead-in and lead-out areas where a plurality of DMA sequences are allocated. As shown in FIG. 13, a medium (optical disk) 1 has a lead-in area A1 on its innermost periphery, and a lead-out area A3 on its outermost periphery. Also, the medium 1 has a data area A2 between the lead-in and lead-out areas A1 and A3.

The data area A2 has a user area UA and spare area SA.

The lead-in area A1 on the innermost periphery comprises first DMA sequences (DMA sequences 1 and 2), and the lead-out area A3 on the outermost periphery

5    comprises second DMA sequences (DMA sequences 3 and 4). In this way, by allocating the DMA sequences on the innermost and outermost peripheries, a plurality of DMA sequences are allocated at physically separated locations.  As a result, DMAs become invulnerable to

10   failures.

FIG. 14 is a flow chart of a reproduction process of a medium on which a plurality of DMA sequences are allocated.  When a medium is loaded to the information recording/reproduction apparatus shown in FIG. 15, the

15   apparatus searches all DMA sequences for currently active DMAs, and reads out defect management information from the currently active DMAs (ST41). That is, in case of, e.g., FIG. 12, the apparatus searches DMA sequence 1 for a currently active DMA

20   (e.g., DMA1), DMA sequence 2 for a currently active DMA (e.g., DMA1), DMA sequence 3 for a currently active DMA (e.g., DMA1), and DMA sequence 4 for a currently active DMA (e.g., DMA1).  The process for searching for the currently active DMA is as shown in FIG. 10.

25   If no defect management information can be read out from any of DMAs due to the influence of failures or the like (ST42, NO), this process terminates

abnormally.   If defect management information can be
read out from the DMAs, the apparatus checks the count
values of the DDS/PDL update counter and SDL update
counter of each DMA.   The currently active DMAs in the

5       plurality of DMA sequences should record identical
information.   Therefore, the count values of the
DDS/PDL update counters and SDL update counters of the
respective DMAs should match.   However, if any failure
has occurred during a process of recording information

10      on the respective DMAs in the plurality of DMA
sequences in turn, some DMAs may remain unupdated.
If the currently active DMAs in the plurality of DMA
sequences have different count values of the update
counters (ST43, NO), the unupdated DMAs match the DMAs

15      having the latest count values (ST44).   In this way,
preparation for recording/reproduction is completed.

        FIG. 15 shows a schematic arrangement of the
information recording/reproduction apparatus according
to an embodiment of the present invention.   This

20      information recording/reproduction apparatus records
user data on the aforementioned medium (optical disk)
1, and reproduces user data recorded on the medium 1.
Also, this information recording/reproduction apparatus
executes a replacement process as needed.

25      As shown in FIG. 15, the information
recording/reproduction apparatus comprises a modulation
circuit 2, laser control circuit 3, laser 4, collimator

lens 5, polarization beam splitter (to be referred to as a PBS hereinafter) 6, quarter wave plate 7, objective lens 8, focusing lens 9, photodetector 10, signal processing circuit 11, demodulation circuit 12,

5      focus error signal generation circuit 13, tracking error signal generation circuit 14, focus control circuit 16, tracking control circuit 17, and main controller 20.

The main controller 20 controls a drive unit.

10     The drive unit includes the modulation circuit 2, laser control circuit 3, laser 4, collimator lens 5, PBS 6, quarter wave plate 7, objective lens 8, focusing lens 9, photodetector 10, signal processing circuit 11, demodulation circuit 12, focus error signal

15     generation circuit 13, tracking error signal generation circuit 14, focus control circuit 16, and tracking control circuit 17.

A data recording process of this information recording/reproduction apparatus will be described

20     below.  The data recording process is controlled by the main controller 20.  Recording data (data symbol) is modulated to a predetermined channel bit sequence by the modulation circuit 2.  The channel bit sequence corresponding to the recording data is converted into

25     a laser drive waveform by the laser control circuit 3. The laser control circuit 3 pulse-drives the laser 4 to record data corresponding to a desired bit sequence on

the medium 1.  A recording laser beam emitted by the

laser 4 is converted into collimated light by the

collimator lens 5.  The collimated light enters and is

transmitted through the PBS 6.  The beam transmitted

5      through the PBS 6 passes through the quarter wave

plate 7, and is focused on the information recording

surface of the medium 1 by the objective lens 8.

The focused beam is maintained in a state wherein it

can form a best small spot on the recording surface,

10      under the focus control of the focus control circuit 16

and the tracking control of the tracking control

circuit 17.

A data reproduction process of this information

recording/reproduction apparatus will be described

15      below.  The data reproduction process is controlled by

the main controller 20.  The laser 4 emits

a reproduction laser beam on the basis of a data

reproduction instruction from the main controller 20.

The reproduction laser beam emitted by the laser 4 is

20      converted into collimated light by the collimator

lens 5.  The collimated light enters and is transmitted

through the PBS 6.  The beam transmitted through the

PBS 6 passes through the quarter wave plate 7, and is

focused on the information recording surface of the

25      medium 1 by the objective lens 8.  The focused beam is

maintained in a state wherein it can form a best small

spot on the recording surface, under the focus control

of the focus control circuit 16 and the tracking

control of the tracking control circuit 17.  At this

time, the reproduction laser beam that strikes the

medium 1 is reflected by a reflection film or

5      reflective recording film in the information recording

surface.  The reflected light is transmitted through

the objective lens 8 in the reverse direction, and is

converted into collimated light again.  The reflected

light is transmitted through the quarter wave plate 7,

10     and is reflected by the PBS 6 since it has a plane of

polarization perpendicular to the incoming light.

The beam reflected by the PBS 6 is converted into

convergent light by the focusing lens 9, and enters the

photodetector 10.  The photodetector 10 comprises,

15     e.g., a 4-split photodetector.  The light beam that has

entered the photodetector 10 is photoelectrically

converted into an electrical signal, which is then

amplified.  The amplified signal is equalized and

binarized by the signal processing circuit 11, and is

20     then supplied to the demodulation circuit 12.

The signal undergoes demodulation corresponding to

a predetermined modulation method in the demodulation

circuit 12, thus outputting reproduction data.

The focus error signal generation circuit 13

25     generates a focus error signal on the basis of some

components of the electrical signal output from the

photodetector 10.  Likewise, the tracking error signal

generation circuit 14 generates a tracking error signal on the basis of some components of the electrical signal output from the photodetector 10.  The focus control circuit 16 controls focusing of a beam spot on the basis of the focus error signal.  The tracking control circuit 17 controls tracking of a beam spot on the basis of the tracking error signal.

The replacement process of the main controller 20 will be described below.  Upon formatting a medium, certification is executed.  At this time, the main controller 20 detects defects on the medium.  The main controller 20 records defect information associated with defects detected at that time, i.e., primary defects, on the PDL in the DMA of that medium.  The defect management information contains a replacement source sector address, and replacement destination sector address.  In normal recording, the main controller 20 also detects defects on the medium. The main controller 20 records defect information associated with defects detected at that time, i.e., secondary defects, on the SDL in the DMA of that medium.  The defect management information contains the addresses of the first sectors of ECC blocks as the replacement source and destination.  Based on the PDL and SDL, an access to the replacement source is considered as that to the replacement destination. The main controller controls the search process of

the currently active DMA shown in FIG. 10, the DMA
registration and update processes shown in FIG. 11, the
reproduction process shown in FIG. 14, and the like.

Additional advantages and modifications will
5    readily occur to those skilled in the art.  Therefore,
the invention in its broader aspects is not limited to
the specific details and representative embodiments
shown and described herein.  Accordingly, various
modifications may be made without departing from the
10   spirit or scope of the general inventive concept as
defined by the appended claims and their equivalents.